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AUTHOR	Moore-Hart, Margaret A.; Liggit, Peggy; Daisey, Peggy
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ABSTRACT

This paper presents a study investigating the effects of the Water Education Training (WET) program on students' performance in science. The WET Program is an after school program using an interdisciplinary approach which has three main objectives: improving science concept knowledge, writing performance, and attitudes toward science and writing. The purpose of the study was to examine the effects of the WET program on elementary students' interest in science, their acquisition of science concept knowledge, and their interest and performance in writing about science. This study involved 291 elementary school students from 12 elementary schools within 10 districts in southeast Michigan. The implementation of the Wetland program and the use of observational, questionnaire, interviews, and survey data, as well as writing samples consistently indicated that the elementary students improved their science concept of knowledge, the writing performance, and their attitudes toward science and writing. Furthermore, the findings from the study reveal that the preservice teachers successfully implemented the WET Science Project as designed. Implications of findings are also discussed. (Contains 38 references and 7 tables.) (MM)

Interdisciplinary Teaching in a Water Educational Training Science Program: Its Impact on Science Concept Knowledge, Writing Performance, and Interest in Science and Writing of Elementary Students

Margaret A. Moore-Hart, Department of Teacher Education

Peggy Liggit, Biology Department

Peggy Daisey, Department of Teacher Education

Eastern Michigan University

Correspondence:

Peggy Moore-Hart
Department of Teacher Education
314 Q Porter
Eastern Michigan University
Ypsilanti, MI 48197
734-487-3260
810-225-2991
TED_MOORE@online.emich.edu

Interdisciplinary Teaching in a Water Educational Training Science Program: Its Impact on Science Concept Knowledge, Writing Performance, and Interest in Science and Writing of Elementary Students

The following study examines how elementary students increase their interest and performance in science and writing through an after-school science program. In response to our nation's commitment that all students will increase their performance in science (National Science Education Standards, 1996), 3 university professors developed an interdisciplinary, Water Education Training (WET) Science Project for preservice teachers to be implemented in after-school sessions at 12 culturally and economically diverse schools. Specifically, the major objectives are to investigate how elementary students improve their: (1) science concept knowledge (2) writing performance, and (3) attitudes toward science and writing.

Perspectives/Theoretical Framework

In an informational world, which frequently focuses on scientific discoveries and technological advances, science performance takes an increasingly important role in the school curriculum. However, the Third International Mathematics and Science Study-Repeat (TIMSS-R) (1999) notes that average science proficiency remains distressingly low.

Growing concerns for scientific literacy in recent years have resulted in a variety of initiatives to improve K-12 science education [e.g., Benchmarks (1993), National Science Education Standards (1996)]. A recurring theme in these initiatives is engaging students in interdisciplinary "hands-on" experiences that integrate science, mathematics, and relevant technologies across the curriculum. Hands-on science learning experiences enable students to become actively engaged in the construction of their knowledge (Lumpe and Oliver, 1991; NRC, 1996; Shepardson & Britsch, 2001). Current studies further demonstrate that combining hands-on science learning experiences with integrated, interdisciplinary programs provides a contextual framework to develop understanding and bring meaning to the learning process in science (Carletti, Girard, & Willing, 1993; Nuthall, 1999; Wallace & Pugalee, 2001). Simultaneously, this approach reinforces skills learned in other parts of the curriculum (Carletti et al, 1993; Short, Harste, & Burke, 1996).

Another theme in these initiatives is engaging students in communication and inquiry processes (Bryce, 2001; NRC, 1996; Short, 1996). Specifically, in learning science, students actively construct explanations of nature phenomena, test these explanations, and communicate these ideas (NRC, 1996). Other studies (Glenn & Muth, 1994; Shepardson & Britsch, 2000) report that writing helps students to better understand science concepts as it helps them organize, clarify, synthesize, analyze, and integrate their existing knowledge with new concepts. Recent research further confirms that writing improves concept development

and retention of information (Baker, 1996; Holliday, Yore, & Alvermann, 1994; Langer & Applebee, 1987).

Other educators (Camp, 2000; Cullinan, 1993; Guillaume, 1998; Lapp & Flood, 1993; Yopp & Yopp, 2000) claim quality literature, written by authors who care deeply and know a great deal about their subject (Cullinan, 1993), is another way to meet the demand of teaching science concepts. Specifically, Lapp and Flood (1993) suggest that students can become familiar with the language and text structure of science while expanding their knowledge of scientific terminology and science concepts through literature. Langer (1995) similarly emphasizes that literature provides another vantage point from which to build fuller understanding of science concepts. Daisey (1996) further reports that biographies of people involved in science draw readers into the lives of scientists. As students read these biographies, she notes that students make strong connections with science material, acquire background knowledge about science concepts and terms, and become inspired and motivated to find out more about science topics. Importantly, the more students read a variety of types of texts related to science, the better they will understand all the texts they read, including more difficult texts found in their science textbooks or more sophisticated science literature (Guillaume, 1998; Lapp & Flood, 1993; Yopp & Yopp, 2000).

Major obstacles toward implementing these initiatives is a lack of science content knowledge by many elementary teachers (Greenwood, 1996) and a lack of knowledge of writing activities that cross boundaries between science and literacy (Bryce, 2001). Other teachers do not recognize that the ideas of science are dynamic and reached through inquiry, communication, and meaningful learning (Lunn & Solomon, 2000).

If we fail to overcome these obstacles, we cannot hope to improve the quality of science teaching. The WET Science Project, an interdisciplinary, science/literacy program, might be one way to strengthen content knowledge and real-life applications of science concepts. Specifically, the WET program, which was implemented by preservice teachers, integrated storytelling, children's literature and science biographies, biology, chemistry, earth sciences, physics, and writing to increase content knowledge about the wetlands and real-life applications of science concepts related to water. The purpose of this study is to examine the effects of the program on elementary students' interest in science, their acquisition of science concept knowledge, and their interest and performance in writing about science.

Overview of the Water Educational Training Science Project

The Water Educational Training (WET) Science Project, designed by the authors, is an interdisciplinary program that promotes science literacy through the theme of water. The project brings together children, preservice teachers, and classroom teachers from 10 diverse school districts in southeast Michigan. Consistent with research (Barton & Smith, 2000; Carletti et al.,

1993; Diamond & Moore, 1995; Nuthall, 1999; Pappas, Kiefer, & Levstik, 1999; Routman, 1994; Wallace & Pugalee, 2001), WET follows an integrated, interdisciplinary framework to strengthen content knowledge about the wetlands and real-life applications of science concepts related to water. Specifically, the program integrates storytelling, children's literature and science biographies, biology, chemistry, earth sciences, physics, and writing through 11 sequential lessons. The lessons, which follow the 5-Step Learning Cycle (engage, explore, explain, elaborate, and evaluate), are implemented in after-school science clubs by preservice teachers. While participating in the science literacy project, learners, ranging in ages from 8 to 11, actively construct a world view of science concepts related to the water theme, based on their prior knowledge, observations, and experiences (Ausubel, 1963).

Seeking to bring real-life learning into the project, we adapted all hands-on learning activities from techniques scientists apply while conducting water studies. Acting as scientists, students acquire the scientific knowledge of the wetlands and wetland ecosystems through inquiry and communication. While participating in authentic, scientific investigations of water, they make observations, formulate hypotheses, and share their results with others through discussions and journaling. To help students make connections to the science concepts they were learning, we used storytelling to role play the biography of diverse scientists or naturalists, who made a significant contribution to wetland or water studies. At the same time, the storytelling activities addressed the needs of culturally diverse students and females, helping them realize exciting careers they might pursue in science related fields and future possibilities that exist in the field of science. Finally, to help students remember and understand the concepts they were learning, we further integrated a variety of writing activities within each lesson.

Method

Participants

The participants for the study consisted of 291 elementary students, as well as their preservice teachers, at 12 elementary schools within 10 school districts in Southeast Michigan. The elementary students, who ranged in age from 8 to 10, were: (1) culturally diverse with a large number of African American students; (2) economically varied, including many who live in poverty; and (3) diversified in gender. Similarly, the 29 preservice teachers were: (1) culturally diverse, with a large number of European-Americans; (2) economically varied; and (3) diversified in gender.

In order to obtain a more complete picture of how the WET science project affected writing about science, we selected a sub-sample of students to be studied in more depth. Consistent with the procedures followed by Graves (1975), teachers selected six students from their after-school sessions to represent high-, average-, and low-ability students, as well as grade level and gender.

Materials

The materials for the WET science project include a Wetland Manual for each preservice teacher, trade books about the Wetlands, Student Journals, and Teaching Tubs. We designed to the Wetland Manual to outline teaching methods/guidelines preservice teachers would follow during the after-school sessions. The manual includes lesson plans that follow the 5-Step Learning Cycle (Trowbridge & Bybee, 1990), various science hands-on learning materials or activities to be used by the students during the sessions, and specific literacy materials or activities to use with the lessons. The Teaching Tubs contain Wetland resource materials, all science equipment for the hands-on learning activities, student journals, and a variety of writing tools (i.e., paper, pencils, pens, markers). The students' journals provide a way for student to communicate their observations, knowledge of the Wetlands, and feelings about what they are learning related to the Wetlands. The Student Journals further track elementary students' writing overtime and provide insight into students' observations, knowledge of the Wetlands, and feelings about what they were learning.

Workshop Sessions

To meet the challenge of elementary teachers' lack of knowledge of science concepts, we created 8 two-hour workshops for the preservice teachers participating in the WET project. Specifically, preservice teachers acquired the knowledge, content, and instructional strategies pertaining to the water theme during 8 workshops spread over 12 months. After designing the content and methods of the workshops to be consistent with recent research in science and literacy, we co-taught the sessions, illustrating ways to integrate science, children's literature, storytelling, and writing instructions through an interdisciplinary approach. During each workshop, we modeled 2 of the lessons preservice teachers would conduct at their respective school sites. Specifically, we modeled science hands-on learning experiences; literacy strategies related to the Wetlands, including choral readings, readers' theater, storytelling, journal writing, writing, and the use of trade books or biographical books. We also provided information related to the science content for each lesson , as well as information related to writing theory, cultural issues, or teaching and learning during the workshops. Throughout the sessions, we provided multiple opportunities for debriefing and reflection. Then, as we planned each successive workshop, we used the insight we gained from the debriefing and reflection sessions to refine and modify our lessons and workshop sessions. In this way, we hoped to meet the evolving needs of the preservice teachers.

Following the first workshops, preservice teachers implemented the lessons modeled during the workshop at their after-school science clubs. To facilitate implementation of the

lessons by the preservice teachers, we placed two preservice teachers with a classroom teacher, who had been trained in the process through another grant, at each school site. Placing 2 preservice teachers at each site allowed them to collaborate their efforts as they planned and prepared the materials for their lessons. In addition to assisting with the supervision of students, the classroom teachers provided preservice teachers ongoing praise and constructive feedback on their teaching effectiveness. To further provide preservice teachers on-site training and coaching, two Teacher Consultants visited each after-school session on 4 occasions. They observed the preservice teachers and students, using an Observation Protocol, and provided feedback, offered suggestions/comments, modeled strategies, or assisted preservice teachers as needed.

After-school Sessions

Constructivist learning theory, an instructional model proposed by Atkin and Karplus (1962), furnished the foundation for the wetland themed lessons implemented by the preservice teachers during the after-school science sessions. These after-school sessions, which were scheduled monthly for 75 minutes, were structured to provide hands-on science experiences for students.

Once preservice teachers attended the initial workshop, they began implementing the lessons at their sites, working in pairs, under the supervision of a Host Teacher. Following the 5-Step Learning Cycle (See Figure 1), preservice teachers began the sessions with storytelling or reading trade books (selected to reflect the cultures of the children). The first step, engagement, stimulated the interest of the learner through storytellers who told about the life of real scientists who contributed to wetland or water studies or through the use of trade books related to the topic of the lesson. The second step, exploration, provided opportunities for students to participate in hands-on exploratory activities. During some lessons, for example, students explored pond water, aquatic plants or animals, or earth sediments from the pond. During other lessons, they participated in experiments related to light and water temperature, soil, or water pollution. The third step, explanation, included opportunities for preservice teachers to give explanations about the phenomena students observed. This was an important part of the lesson during which time preservice teachers developed science concepts and skills related to the wetland theme and reinforced concepts and skills from earlier lessons. The fourth step, elaboration, actively involved students in their learning as they consolidated their learning through writing and discussion activities. For example, students talked about what they explored and learned in large groups, small groups or pairs; they wrote explanations in their journals or created graphics to illustrate the science concepts; they drew illustrations of animal or plant life they investigated; or they illustrated and labeled various experiments they conducted. All lessons culminated with the fifth step, evaluation, which included a variety of writing-to-learn

or creative writing activities. Using their science journals, graphic organizers, concept maps, or webs from the exploration and elaboration stages, students synthesized their understanding of the concepts presented in the lesson through written explanations, stories, letters, or poems.

The sequence of the lessons for the Wetland Project began with a focus on the biology of wetland habitats through explorations of pond water, discovering wetland food webs, and experimenting with aquatic and terrestrial plants. As the lessons continued, the focus moved to chemical changes in the wetland ecosystems through scientific investigations related to soil and ground water pollution. The lessons concluded with explorations of the effects of light and temperature on wetland habitats and organisms. In addition, all lessons included objectives and content standards identified in both the National Science Education Standards (National Research Council,1996) and the Michigan Curriculum Frameworks (1996). Importantly, the combined activities, which evolved during each stage of the lesson and with each sequential lesson, enhanced understanding of the complex concepts so that students might retain the information over time.

Data sources and analysis

The data collection period extended from September 1999 to May 2000. During this period, information was gathered using multidimensional sources. The data sources included: (1) students' science-related and writing-related performance changes, assessed by the Observational Protocol; (2) students' science- and writing-related attitudes, assessed by the Science and Writing Self-Perception Scale; (3) parent and host teacher judgments about changes in students' science and writing attitudes and performance, assessed by parent and teacher questionnaires; (4) student attitudes and performance, assessed by structured interviews of students, preservice, and host teachers; and (5) writing performance, assessed by writing samples from the sub-sample.

All interviews were tape-recorded and later transcribed. Responses from the questionnaires and interviews, as well as the observations from the Observation Protocol, were then analyzed using the constant comparative method (Glasser & Strauss, 1967; Miles & Huberman, 1984; Patton, 1990). Patterns and themes related to teaching and learning were noted and compiled in order to identify: (1) changes in students' attitudes toward science and writing, (2) changes in students' performance in science and writing, (3) changes in students' concept knowledge, and (4) factors that influenced changes in students' attitudes or performance. Similarly, to analyze the writing samples, the constant comparative method was followed to identify changes in the sub-samples' writing performance. Credibility of the study was further strengthened through team collaboration and prolonged and persistent analysis and synthesis of the data.

Finally, to analyze science- and writing-related attitudes, assessed by the Science and Writing Self-Perception Scale, analysis of variance was performed. Since a review of related research did not reveal an existing science- and writing-related attitude survey pertaining to the wetlands, the authors designed the survey. The Science and Writing Self-Perception Scale consisted of 16 items to which the participant responded, using a five point rating scale (1= Strongly Disagree, 2 = Disagree, 3 = Undecided, 4 = Agree, and 5 = Strongly Agree).

Results

As a result of the Wetland program, observational, questionnaire, interview, and survey data, as well as the writing samples, consistently indicate that the elementary students improved their science concept knowledge, their writing performance, and their attitudes toward science and writing. Importantly, the findings further reveal that the preservice teachers successfully implemented the WET Science Project as designed.

Implementation of the WET Science Project

Observational, interview, and questionnaire data consistently revealed that the preservice teachers implemented the wetland lessons within their after school sessions, following the format of the lessons (Engage, explore, explain, elaborate, and evaluate). Data further revealed that they delivered interesting, stimulating, and informative after-school sessions for the elementary students. While implementing the lessons, the preservice teachers further applied the science and literacy strategies modeled during their workshops. For example, they used hands-on learning activities to teach the science concepts, prewriting activities to help students write about the science concepts they were learning, modeled writing strategies and techniques to record observations or reflections about science concepts, used praise and questioning to support the students as they wrote, and provided clear explanations about the science concepts to the students. Data further revealed that preservice teachers:

- showed strong rapport with their students
- maintained the interest and motivation of the students in science literacy
- used praise and encouragement to support students
- modeled enthusiasm and a love for science, reading, and writing
- showed a positive attitude to support the learner
- helped children increase their self-esteem
- helped students become more comfortable with writing
- circulated among the students to monitor learning and assist them as needed

Observation, interview, and questionnaire data further revealed that students demonstrated interest and motivation in the lessons throughout the session. Data suggest that elementary students:

- demonstrated engagement in the activities
- demonstrated the ability to explore and experiment their environment using scientific materials and tools
- retained information and knowledge about the wetlands over time
- demonstrated more comfort with writing in science

Interestingly, data from the multiple sources also suggest that many girls became more interested in science through the use of storytelling, literature, drawing, or writing activities. Similarly, data suggested that culturally diverse students became more motivated/interested in science learning through the use of storytellers, literature, or stories that reflected themselves.

Findings Related to Elementary Students' Interest in Science

Observational, interview, and questionnaire data illustrated that elementary students participating in the after-school program improved their attitudes toward science. All data sources showed that students were motivated, highly engaged in the lessons, and well behaved throughout the lessons. As one host teacher pointed out, "When kids are interested in the subject, they behave better and try more." Another explained, "The children tell their friends about the program and bring them into the room. I have kids asking me to join even at this date." Similarly, parents reported, "She talks about the project and how much fun she had." ; "He enjoys going to science club and talks about it all the time." Or "Her overall attitude towards science is very positive now." These remarks are also consistent with the students' comments. For example, one student shared, "I feel good and I like it because I get to learn new things." Another similarly noted, "It's fun to be with my friends after school, and I like the experiments. I think we're going to do it next year." Still another stated, "I think it's really good."

Perhaps interview data from preservice and host teachers, students, and parents provides insight into why students were highly interested and motivated in the lessons. For example, preservice and host teachers observed that the use of story telling and children's literature at the beginning of the lesson captured the interest of the students and helped build background knowledge in the lesson. For example, one host teacher shared, "The storyteller was a good idea. The kids really seemed to like hearing about the history and biographies." Similarly, parents commented, "She enjoys listening to the storytellers who have come." Students also

shared, "The storytellers were great." The data further showed that the use of hands-on learning experiences during the exploration stage of the lesson made the learning of science fun and engaging for the elementary students. For example, one host teacher shared, "The kids really enjoyed digging into bowls of pond water, and they enjoyed finding animals and plants on the Pond Guides." Another noted, "The kids enjoyed the experiments." Similarly, parents reported, "He like the hands-on activities and the topics they explored." Or "She enjoys doing the experiments and observing many different things." Other parents further explained, "My son wants to do experiments all the time now." or "My daughter is trying to do every experiment with water she can." The students' comments further show how much they enjoyed the hands-on experiences. For example, one student shared, "I like the experiments because they brought in lots of things that we could touch and that we could do." Another reported, "I liked doing experiments and drawing what we think we saw."

Importantly, the questionnaire from host teachers and parents further confirm that the students' attitudes toward science were improving. According to the questionnaires, 98% of the teachers and parents reported that the children talked about the WET program; 91% of the teachers and 95% of the parents believed that the children were positive about the program; and 100% of the teachers and parents believed that children improved their attitudes toward science. Tables 1 and 2 display the findings related to teachers' and parents' beliefs about the program.

Finally, the Science and Writing Self-Perception Scale further shows students' positive feelings about science on pretest and posttest conditions, ($\underline{M} = 4.5$ and $\underline{M} = 4.6$, respectively). Similarly, the findings reveal positive feelings about the importance of learning in science ($\underline{M} = 4.8$ and $\underline{M} = 4.9$, respectively). Nevertheless, the findings did not indicate a change in students' feelings about science, nor a change in their feelings about the importance in learning about science. However, results of the analysis of the data comparing pretest and posttest conditions suggest students' comfort with learning science concepts significantly increased ($\underline{F}[1, 136] = 9.89$, $\underline{p} < .002$).

Findings Related to Elementary Students' Knowledge and Understanding of Science Concepts

The multiple sources of data consistently reveal that the elementary students increased their knowledge and understanding of science concepts. Preservice and host teachers both shared that they were impressed to see that students remembered the concepts they were learning from one lesson to the next. For example, one preservice teacher noted, my students are remembering what they learn from one session to the next." Another reflected, "When we were doing the journals, a lot of kids were naming off creatures from the very first lesson, so they have definitely been learning." Many preservice and host teachers also observed that "The more they talked about what they learned, the more it seemed to stick with them." Many also felt that the

structure of the lessons and the writing component helped students learn the information. One host teacher pointed out, "Brainstorming and listing reinforced concepts." Similarly, a preservice teacher noted, "When you ask them to observe without writing their observations, they don't say much. When they have a blank sheet in front of them to fill, they dig deeper."

Closer inspection of the data revealed that both preservice and host teachers believed that the integration between the writing and science helped children understand the science concepts better. One preservice teacher, for example, explained, "Writing may be hard for them, but it gets stuff stuck in the brain, and that's the whole point of the exercise!" Similarly, a host teacher observed, "Brainstorming and listing reinforced concepts." These comments were consistent with the students' remarks. Students, for example, shared, "You wouldn't learn as much if you didn't write it all down" ; "Writing helps you to understand it better and understand what we know better." ; "Writing helps me remember what I learned because I had to think about it more when I wrote about it." or "Writing helps you think about the different kinds of things you learned and have something to look at if you forget."

Likewise, the findings on parent interviews revealed changes in students' knowledge about science concepts. For example, parents reported that their children talked about the wetland, environment, and pollution with them at home. Some reported their children could now recognize scientific things and how they develop; others explained that their children talked about what plants and animals they might find in creeks or wetland areas located close to their homes. Examples of quotes include, "My son recognizes scientific things now and how they develop." Or "We live near a creek and my daughter can tell us a lot about what we find in it."

Students' responses similarly show the knowledge they acquired. One student explained, "I learned that over 100 different kinds of animals live in the wetland." Others reported, "I learned that wetlands was a combination of different parts-plants and animals together. There's a high grassy part, then a lower part, then a swampy part." or "I learned if we are not careful, we won't have clean water when we get old."

Importantly, the host teacher and parent questionnaires reveal that the teachers and parents believed that students had increased their science concept knowledge and science knowledge about the wetlands. According to the questionnaires (See Tables 1 and 2), 91% of the teachers believe that children are improving their knowledge about science and their knowledge about water and the environment. Interestingly, 97% of the parents believe their children are improving their knowledge about science and their knowledge about water and the environment.

These findings are consistent with the findings from the Science and Writing Self-Perception Scales. Specifically, results of the analysis of the data comparing pretest and posttest conditions indicate students' knowledge about the wetlands, uses of water, and pollution significantly increased ($F[1, 132] = 13.795$, $p < .0001$), ($F[1, 132] = 8.769$, $p < .004$), ($F[1, 132] = 17.194$, $p < .0001$).

Student interviews provide additional insight into students' knowledge about the wetlands, uses of water, and pollution. Specifically, students were able to easily use and talk about the scientific vocabulary related to the wetlands. Some students were also able to explain concepts. For example one student explained how water becomes polluted. Table 3 displays examples of students' quotes about what they learned.

Findings Related to Elementary Students' Interest in Writing

Observational, interview, and questionnaire data suggest that elementary students participating in the after-school program were changing their attitudes toward writing. However, this change occurred over time. For example a host teacher explained, "The kids like to write and felt safe with the methods. They were interested in the topic which made it easier to get them to write." And another commented, "The children enjoyed writing about what they learned and didn't complain about it." Likewise, a preservice teacher noted, "The students were very motivated and enthusiastic about writing." or "The children were very proud of their writing and wanted me to read all of theirs to the group."

In addition, host teachers and preservice teachers noted that the more the children wrote, the more comfortable they became with writing. For example, one host teacher observed, "As time went on, and as we continued to explain that scientists must write their observations down all the time, the children became more comfortable with writing. It became second nature." Similarly, a preservice teacher shared, "My students are really coming around to the writing process." Parents also reported that their children enjoyed the writing. For example, one parent remarked, "She likes to write and do the experiments."

The quotes from the students similarly show that students' attitudes toward writing was changing. For example, students shared, "I really like writing! It is fun and important." or "I like to take notes, because I remember better when I do that." Some of the students' struggles with writing were also revealed in the interviews, as shown by this student, "I sort of enjoy it—I have trouble putting my thoughts down on paper, though."

The findings on host teacher and parent questionnaires also reveal that teachers and parents believed that students' attitudes toward writing increased. According to the questionnaires (See Tables 1 and 2), 91% of the teachers and 83% of the parents believe that children's attitudes toward writing are improving.

Even though the data indicates a change in attitudes toward writing, data also suggest that writing was challenging for many of the students. Some students continued to even question whether they liked writing. For example, some students commented, "It's okay…I don't like it a lot."; or "I don't like writing." In contrast, other students shared, "I really like writing! It is fun and important." or "I just like to write."

Although student interview data revealed some variation in their feelings about writing,

students consistently noted certain teacher behaviors that helped them write better. Specifically, they stated:

- "It helps when my teacher gives us webs or questions."
- "It helps when teachers brainstorm. It helps you know what to say."
- "It's easier when my teacher writes stuff on the board, like a map or a web. That helps us figure out what to say. Listening to the teachers' ideas and other kids' ideas is good, too."
- "It's easier when my teacher made lists, drew pictures, and wrote down names of things so we'd know how to spell them. She made a map showing how the tanks polluted the water and the well."
- "I like the forms... 'First I learned this, then I learn that,' or when they wrote on the board, or when we could write a story about what we learned. I like writing stories best."

These statements indicate the importance of modeling, prewriting activities, and scaffolding when students are writing in science.

The findings on students' attitudes toward writing are further consistent with the results of the analysis of the Science and Writing Self-Perception Scales. The findings, indicate students enjoyed writing in science on the pretest and posttest conditions ($\underline{M}$ = 4.2 and $\underline{M}$ = 4.3, respectively). Similarly, students believed that writing in science was important ($\underline{M}$ = 4.3 and $\underline{M}$ = 4.3, respectively). However, the findings did not indicate a change in students' feelings about writing in science, nor a change in their feelings about the importance of writing in science.

Findings Related to Elementary Students' Writing Performance

The writing samples, as well as data from the multiple sources, suggest that students became more comfortable with writing in science contexts. Over time students began to write longer journal entries that included more detailed observations of their science explorations or experiments. They also began to add more details and examples in their writing pieces about the wetlands. This change in both quantity and quality is also reflected in both preservice and host teachers interviews. Preservice teachers pointed out, "The journals have come a long way. There is more volume and higher quality of writing. This shows improvement for me." ; "The students are taking better notes, drawing more detailed pictures." or "The children have shown tremendous improvements in their writing—both in quality of writing and in their attitudes." Similarly, host teachers noticed that students were writing more and they were using more details and examples in their writing. For example, one host teacher shared, "The writing improved over the course of the year, both in length and detail." Another commented, "I think the students write more, and it seems to be better quality."

In addition, preservice and host teachers emphasized that students improved their ability to use writing to observe, compare, analyze, and synthesize scientific information. The presence of change might be illustrated by one host teacher's remark, "They're better thinkers and better writers as a result of the program. They're more analytical than they were at the outset." Similarly, students' comments in their interviews illustrate that they feel they are acquiring these skills. For example, students shared, "I like when we compared different animals to each other and wrote stories about nature." Or "I liked writing about the experiments, observations, hypotheses."

These findings on the observation, questionnaire, and interview data are consistent with the findings from the writing samples of the sub-sample. For example, the writing samples (See examples of writing samples in Tables 4, 5, 6, and 7) illustrate students' knowledge of science concepts and the wetlands. As students drafted their ideas, they used the science vocabulary related to the wetlands—duckweed, caddis fly, food web, elodea, or osmosis. Their writing also included examples and details about the wetlands or about the experiments, showing their understanding of the concepts. For example, one student wrote, "We found out that the iodine was going into the mixture and turning it purple because cornstarch and iodine make things purple." Another student wrote a letter to the President, insisting that he "try as best as you can to stop acid rain." Her suggestions for stopping acid rain included, "use solar power and do not burn fossil fuels, or you could put filters in smoke stacks to make sure the it cannot turn into acid."

Analysis of the writing samples also reveals that the length of the written responses increased over time. Importantly, the writing samples of students at all ability levels gradually began to include more descriptive words and more details about the wetland environment or examples to support and illustrate their ideas. For example, In his piece Iman described the wetland environment with details and descriptive words "Duckweeds can carpet a pond's surface. A water strider is supported by surface tension. A cadesfly larva provides cameflage and protection..." Similarly, Alex describes the swamp: "The water is murky,slimy, and smells fresh. The cattails are so fluffy and about to explode..." Specifically, the results of constant comparative analysis revealed that students:

- increased the number of details in their written observations of wetland environment in their journals
- increased the number of notes in their journals
- increased the number of words in their prewriting lists or webs
- increased the number of words in their written responses about the wetlands
- integrated more scientific vocabulary related to science and the wetlands into their written responses
- integrated more details and examples into their written responses

- integrated more descriptive words into their written responses

Tables 4, 5, 6, and 7 provide samples of children's writing. The writing samples within the tables, which are arranged from high ability students to lower ability students, reflect how students of various ability levels record their ideas.

The tables also display some of the genres of writing used by students during the sessions. Importantly, students liked having choices on what they wrote and how they wrote. For example, one student shared, "I liked choosing what I want to write. Once I wrote an acrostic poem about a cattail." Another student, however, noted, "I liked writing about the experiments, observations, hypotheses." Students also enjoyed using different genres for their writing. One student pointed out, " I liked writing letters to the companies about why they shouldn't pollute because it causes acid rain. I wrote to Ford Company." Still another stated, "I liked writing in our journals about the wetlands and writing poems about the wetlands." While another shared, "Writing stories was the best!"

Even though, the findings suggest that students of all ability levels improved their writing these changes occurred gradually because writing was troublesome for some students. Some students continued to even question whether they liked writing while others shared, "I like writing; it's easy for me." or "I like doing experiments, writing, and learning."

Implications

Consistent with research (Carletti, Girard, & Willing, 1993; Nuthall, 1999; Wallace & Pugalee, 2001), the findings reveal that using an interdisciplinary program, which includes hands-on learning experiences and literacy experiences, can promote students' performance in science and literacy. Using literature, storytelling, and writing with hands-on science experiences provided another way for students to understand these complex concepts. Similar to other research studies (Daisey, 1996; Guillaume, 1998; Langer, 1995) the interdisciplinary approach also inspired and motivated students to learn about the science topics. Some students even expressed an interest in becoming a scientist.

The findings also reveal the impact of integrating science with writing, which seemed to heighten students' higher level thinking skills and concept development in science. Similar to Shepardson's and Britsch's study (2001), the findings suggest that writing helped students gained a deeper understanding of the science concepts. Writing, especially journal writing that includes observations, webs, charts, or graphs, further helped students understand and retain science concepts.

Even though writing benefits students understanding and retention of information, writing is troublesome for many students. Others resist writing or remain unsure if they like writing. This will continue to challenge teachers to remain patient and supportive of their students as they write. Since writing requires high level thinking and deep processing of information, teachers

will want to follow writing theory, using modeling, prewriting activities, and scaffolding.

Similar to other studies (Butler, 1990), an interdisciplinary approach to teaching science especially appealed to girls and culturally diverse students. Of interest, the findings suggest that storytelling, literature, drawing, and writing increased many girls' interest in science. Similarly, the use of storytelling and biographies motivated culturally diverse students' interest in science learning. If we want to encourage more females and culturally diverse students to pursue careers in science, this may be one avenue to explore. Future studies need to be specifically designed to examine what instructional strategies motivate and encourage girls and culturally diverse students in the sciences (Parker, 2001; Ryan, 2001).

As educators make efforts to integrate writing with science, however, they will need to retain the integrity of their content areas and their literacy. Each requires dedicated instruction if students are to become proficient learners (Lapp & Flood, 1993; Wallace & Pugalee, 2001). Teachers will need to focus on the processes and standards related to the various disciplines and the instructional strategies that positively impact children's learning. Teachers will also need support in order to integrate curriculum in meaningful ways.

It further appears that after-school programs might be a cost-effective way to increase science learning of children. There will be an ongoing need to evaluate and identify effective programs so that these opportunities may be extended to other students across the nation.

Table 1. The Wetland Project and Its Impact on Students' Attitudes and Knowledge about Science and Writing According to Host Teacher Questionnaires

- Children talked about the WET after school program (98%)
- Children said positive things about the after school sessions (91%).
- Children are improving their attitudes toward science (100%).
- Children are improving their attitudes toward writing (91%).
- Children are improving their knowledge about science (91%).
- Children are improving their knowledge about water and the environment (91%).
- Children are improving in other areas (65%).
- Children benefit from the program (91%).
- Teachers would continue to have their children participate in the WET after school program (91%).

Table 2. The Wetland Project and Its Impact on Students' Attitudes and Knowledge about Science and Writing According to Parents

- Children talked about the WET after school program (98%)
- Children said positive things about the after school sessions (95%).
- Children are improving their attitudes toward science (100%).
- Children are improving their attitudes toward reading (93%).
- Children are improving their attitudes toward writing (83%).
- Children are improving their knowledge about science (97%).
- Children are improving their knowledge about water and the environment (97%).
- Children are improving in other areas (65%).
- Children benefit from the program (93%).
- Parents would continue to have their children participate in the WET after school program (93%).

Table 3. Examples of Students' Knowledge about Science According to Student Interviews

- "I learned a lot about the creatures (insects) of the wetlands. I also learned that salt hurts the creatures by disintegrating the eggs and the shell."
- "I thought wetlands were just swamps. But a swamp is a wetland. The lady from Florida talked about a book, and a scientist came with her first microscope. He father gave her the microscope. Her father and brother and sister would look at stuff under the microscope."
- "I learned about the animals and how important it is to keep the wetlands clean. We need to keep it safe for us and the animals."
- "I learned if we put food in the water, it could kill certain kinds of fish. I also learned that acid rain is caused by smoke from factories and cars."
- "I learned that nothing can live without water, and we have to stop putting salt in it so we can be healthy and the plants won't die, either."
- "I learned that when holes get poked into a barrel, and it leaks out, oil and stuff goes into the ground and the water underground."
- "I learned that people put acid and gas and stuff in the ground. The metal rusts, the stuff spills out and it gets into pipes and water and hurts the groundwater."

Table 4. Samples of Student Writing: Exploring Life in a Wetland Habitat

I learned about the wetlands and all sorts of water. I think the neatest thing was the tadpoles. The bugs were neat too. There were all different kinds of bugs. I learned how neat water can be. I think it looks cool and fun to learn about. I like the duckweeds. I think water is most important because you can grow food with water. And you can grow trees and cut them down and make a house.

By Nasreen

The first thing was I looked inside the water to see what was in it. Second I wrote my picture about what I seen inside the bowl. Then I looked again and I wrote and draw it. Next we looked at the water bug map to see what we might see. Last thing I did was draw something.

By Katie

Today I learned a lot about wetlands and saw some insects and organisms that live in wetlands. Like backswimmers, tadpoles and fishing spiders. I am going to learn a lot more.

By Kurtis

Table 5. Samples of Student Writing: Energy Flow in a Wetland Ecosystem

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I found out if one of the animals in the food chain dies the whole chain dies. If a whole food chain dies we will have no animals. And if we have no animals people will not have any meat on their bone. And if they do not have any meat on their bones everybody will die.

Chelsea

I learned about a food web. I learned that if we even let one animal out, then it would be wrecked. It was fun learning about food webs. We even played a game. We heard a story about the food web. We had fun.

By Maggie

To day I learned if one person lets go of a web, the whole thing would be ruined. We played a game.

By Steven

Table 5. Samples of Students' Creative Writing

This is the pond. This is the pond where the cattails grow . This is the pond where the cattails grow, where the muskrat eats the cattails. This is the pond where the cattails grow, where the muskrat eats the cattails, where the mink hunts the muskrat. This is the pond where the cattails grow, where the muskrat eats the cattails, where the mink hunts the muskrat, where the bass hunts for the mink. This is the pond where the cattails grow, where the muskrat eats the cattails, where the bron, furry, and soft mink eats the muskrat, where the bass eats the mink, where the King Fisher eats the bass. When the King Fisher dies, he is decomposed.

By Paige

Snail
Small, round bug
Sticks to a lot of things
Carries his home on his back
When scared, goes in
He eat tiny things for a snack
He climbs on seaweed
He almot got eaten by a duck by the seaweed
Snail
By Ariel

One day I was walking in my garden where there was water. I noticed that duckweeds were growing. Then I heard a bumblebe and frog. Then the frog ate the bee.

By Jake

Table 6. Samples of Student Writing: Aquatic and Terrestrial Plants

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They both are green They both need water. They both are plants. They both have leaves. The soybean plant is hard. The elodea is soft. One plant grows in the ground which is the soybean plant and the other plan grows in the water which is the elodea. The soybean plant has dirt and the elodea has water. They both breath oxygen. One has a lot of leafs and one has barely any. They both are long. They both need water.

By Karima

Elodea

It's green with lots of leaves and sticky
It is very wet
Of course it need the sun and water
But it does not need soil
It grows roots on the side.

By Justin

I learned that some plants have some things in coman. I also learned that a elodea lives in water. Plants need to live in water or soil.

By Kylie

Table 7. Samples of Student Writing: Letters about Pollution

Dear Mr. President,

I think you should make a big law that would stop people from throwing things around. You should make a law that when you are in a boat you should not throw stuff in the water, because animals are dying. You should also make a law that tells people not to pollute. I think people should throw their stuff in the trash, not on the ground or oceans. We all need to help clean up the oceans and the grounds. If people have cans, cups, paper or other trash, they should throw them away.

I hope you make these laws to make the earth better and help keep the animals alive.

Thanks for listening,

Jena

Dear Factory Owners,

Can you stop using fossil fuels? Can you stop polluting our earth? Pollution is making our animals real sick and ruining our homes. And when you use paper, use recycled paper? Also when your employees come to work could you use a battery car.

Your Friend,

Jacob

Dear Factory Owners,

Please stop putting pollution in the air. All of the pollustion goes on the land, the trees, and even us. It also hurts the wetlands. Please help us and stop.

Sincerely,

Nina

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